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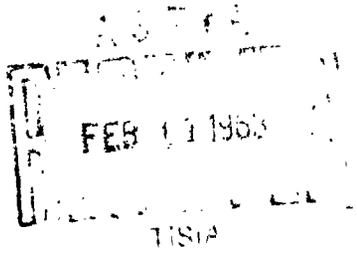

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International Scientific Life

Achievements of Medicinal Electronics

By

Ye. B. Babskiy; V. V. Parin

(Briefs from the III International Conference on Medicinal Electronics)

In the last decades, particularly in the postwar years, are noticed outstanding achievements in the employment and utilization of electronics in physiology and medicine. A new scientific discipline - medicinal electronics came to being. In connection with its greater and constantly growing importance various countries have established special scientific societies, devoting their activities to study and evaluation of numerous and different applications of electronics in biology and medicine. In the USSR a similar scientific society in existence since 1959 is the section of medicinal electronics of the Scientific-Technical Society of Electronics and Electrocommunication named after A. S. Popov. In England in 1960 was founded an analogous union of biologists, medics and engineers under the title "Biological Engineering Society".

The very same purpose is being served by the yearly, for the past three years, International Conference on medicinal electronics, called by the organized in 1958 International Federation of Medicinal Electronics.

Members of the International Federation appear to be representatives of various medicinal and biological specialties,as well as physicists and engineers,engaged at scientific and practical undertakings and at industrial enterprises. All these - biologists and physiologists,therapeutists and surgeons,obstetricians-gynecologists and

radiologists, specialists in electronics and radio engineering - representatives as it would appear of distant from each other scientific disciplines- are united in this case by the interest of applying electronics in biology and medicine. This interest to the new field of knowledge grows rapidly the best proof of which is that: at the first international on medicinal electronics held in 1958 there were only 50 persons present, while on the last conference - third conference-,which was held at the end of July 1960 in London, there were more than 800 participants.

At the twenty sessions of the sections and symposiums of the London conference more than 130 reports have been presented. They were devoted to medicinal and engineering problems, originating during the development, manufacture and utilization of electronic instruments,intended for biological and medicinal investigations,particularly for the study of functions of the nervous system, locomotorial apparatus, blood circulation systems, respiration, digestion etc. Special sessions and special attention were devoted to radiobiological problems, effect of ultrasound and microwave radiation on the organism.

A graphic illustration of modern achievements of medicinal electronics technology and a supplement to theoretical materials of the conference was the greater display of devices, in which more than 60 European and American companies have participated.

In the reports at the plenary session during the opening of the conference and the first section meetings was given a general review of the present state and ways of developing medicinal electronics. Of special interest was the reviewing report by the president of the international federation of medicinal electronics and initiator of international conferences, devoted to this field of knowledge, V.K.Zvorykin. On numerous examples were shown the basic tendencies in the development of electronics in general and medicinal electronics in particular. One of these appears to be an effort to produce miniature apparatus,appearing in the reduction of overall dimensions of electronic instruments and reduction in energy required by them. The technical bases of producing miniature instruments and devices is broad introduction of

semiconductors. It was noticed, that medicine can figure that in the nearest future will be created such instruments, which can be introduced into various organs of the bodyand, which as result of their extremely small dimensions, will not distort the functionsof physiological processes. As an example, or more truly as a prototype, of similar instruments can serve miniature radio transmitters (radio globules), introduced into various hollows of the organism and emitting information about the function of certain physiological processes, and miniature microphones and electromanometers, introduced into the hollow of the heart and blood bearing vessels and serving for registration of intraheart tones and noises and intracardiac and arterial pressure .

The use of semiconductors and small electric power sources in form of miniature silver-zinc or oxymercury accumulators and batteries enabled to produce small and light weight electronic stimulators which could be inserted into the body, and sending toward the heart electric stimuli of definite given rhythm.

These stimuli, replacing natural physiological pulses, normalize the activity of the heart in patients at certain disruptions of the cardiac rhythm. At present time is no longer unfounded the fantastic idea of producing small scale instruments of the type of an artificial heart, lungs or artificial kidneys, which will be inserted in the organism in form of functional prosthesis.

Another leading tendency of medicinal electronics is the sharply expressed effort to produce automatically functioning instruments. No doubt, that automation will penetrate more and more into the activities of medicinal personnel of hospitals, ambulatories and clinical laboratories. Already now into practice are being introduced electronic base instruments to calculate the compositional elements of the blood, to analyze gaseous composition of air, to determine certain chemical ingredients of the blood and other fluids of the organism, potentiometric titration etc. Of greater practical importance is the possibility at present time to centralize in the cabinet of a doctor on duty or in the room of a nurse the measurement of temperature, investigation of pulse and electrocardiographic observation of the conditions of patients.

situated in especially equipped rooms. Such an apparatus considerably improves the quality of medicinal service of patients.

As was shown in the conference reports, modern medicine is employing electronic computers. Similar devices (of continuous action) are used to solve certain problems of physiology and pathology of blood circulation and respiration, to study the reflectorial activity etc. Of greater theoretical value is electron modeling of certain processes taking place in the organism . In this way it is possible to check the correctness of certain theoretical formulations and come closer to the understanding the nature of action of control mechanisms. At the conference was presented a lecture by Windheim and Etkins, who made an effort to solve biothermal problems of human physiology with the aid of continuous action computers.

Variegated can be the use of digital computers in medicine. Experience is already available on the use of electric diagnostication machines in certain limited fields of medicine - in hematology and ophthalmology. It is necessary to consider as perfectly real the perspective of creating electronic diagnostication computers and "therapeutic" machines , designated to aid the doctor in diagnosing complex cases of certain rare diseases and to determine the most suitable therapy. Logical operating circuits of such machines are based on the compilation of available medicinal data concerning the symptomatics of definite diseases with symptoms, displayed by the given patient, and comparison of the observed disturbances with the action of various drugs. Highly perspective is the use of computers in the solving ofproblems of medicinal statistics.

As was correctly stated by Zvorykin, the development of electronics may lead to a radical change in medicine. But electronic technology will never be able to replace the doctor with his individual and universal approach to the patient, although it will equip him with enormous additional possibilities in his struggle for health and life of humans.

Certain interesting reports were devoted to the use of TV in biology and medicine.

The report by Berkley concerning an ultraviolet TV microscope derves special attention. Illumination of the investigated object in this microscope is realized from a source of ultraviolet rays.

The microscope is connected with a TV system, thanks to which the image of the animal obtained in the eyepiece of the microscope, the image of an unfixed object, can be observed on the screen of a color TV set. The various colors correspond to specific wavelengths of the ultraviolet spectrum. The feature of the ultraviolet TV microscope is that the intensity of the ultraviolet illuminated object in it is reduced considerably, and this offers the possibility of long lasting investigation of living structures. The report by Berkley was accompanied by a demonstration of a well prepared and highly demonstrative motion picture film.

Of special importance is the use of TV-technology in x-ray investigations. The Marconi company produced and x-ray TV installation, revealing new perspectives for medicinal roentgenology and appears to be a greater step forward. This arrangement consists of an ordinary x-ray apparatus, above the table of which is mounted a wide tube with x-ray screen, system of mirrors and lenses and TV perception tube "ORTIKON". The image obtained on the screen of the x-ray apparatus is guided to the perception TV tube and can be examined on the screen of an ordinary televisor. With the aid of an electronic apparatus is attained greater magnification of brightness and contrast of the image. X-ray examinations can be carried out in a room, in which the patient is situated, and in any other point of the hospital as well. The advantages of this installation in comparison with an ordinary x-ray apparatus are: 1) considerable reduction in dosage of x-ray radiation, to which patient is subjected, 2) a reduction to a minimum of medicinal personnel exposure, 3) greater than ordinary legibility of image, 4) no need of darkening the room and no dark adaptation of the roentgenologist, 5) possibility of demonstrating x-ray picture for a considerable number of people, situated at a distance from the x-ray cabinet.

Ingram reported about the use of the electron resonance principle to study biological problems. It was shown in the report that on the basis of electron resonance phenomena, there is the possibility of establishing the qualitative and quantitative characteristic of free radicals, appearing in the process of metabolism in the organism. Obtained were data on the appearance of such radicals during photosynthesis , during fermentation processes, during the growth of malignant tumors. This method also enabled to investigate the structure of certain metal organic compounds in the organism, e.g. hemoglobin. Even though electron resonance investigations in biology are in their very initial stages, yet there are bases to anticipate from these investigation greater results to penetrate into the gist of intimate physico-chemical processes, taking place in vital phenomena. It is necessary to point out, that in the USSR works on the use of the principle of electron paramagnetic resonance in biology are being successfully developed at labs headed by L.A.Blyumenfel'd.

Interesting was a report by A.Hopkins concerning methods of determining dielectric losses in small quantities of biological materials and their ratio to the amount of water in the tissues. The principle of the method consists in determining the amount of heat, forming in the tissues of the organism upon the absorption of definite in frequency and intensity oscillations of radiowave range.

To make an investigation it is sufficient a total of 100 mg of tissue. The absorption spectrum reveals the characteristic changes , depending upon the ratio of free and bound water in the tissues.

A number of interesting reports has been devoted to problems of electrophysiology, particularly to methods of analyzing bioelectric phenomena. In the reviewing report by A. Monnie was given a historical outline of the development of electrophysiology, and the exclusive high value of applying the achievement of electronics in this field, was shown. The employment of amplifiers, cathodic oscillograph and microelectrode technology has entire changed electrophysiology. The development by physiologists of cathode repeaters, necessary to separate the biocurrents from

the individual nervous cell, having very high impedance, was found to be useful also for technology. The lecturer- an outstanding electrphysiologist - insisted upon the necessity of close cooperation between electrophysiology and electronics, since such a cooperation is useful for both parties.

In several reports, particularly in the report by R.Cooper and V.Grey-Walter were explained analysis and processing methods for neurophysiological information with the aid of computers. In this way, is assured high reliability and rapidity of obtaining results, as well as greater time economy for qualified workers. Developed were methods for partial spectral analysis of relatively fast as well as very slow (from 0.004 to 0.6 c) oscillations of the potential.

And in conference reports and during the instruments fair have been presented modern methods of analyzing electroencephalograms. Developed was a series of instrument models,allowing to obtain automatically a frequency spectrum of biopotentials of the cortex cerebri. Constructed were also several different models of topoelectroencephaloscopes. Attention is merited by a toposcope developed in Whitechair hospital in Cardiff. This instrument is intended for 100 pickups. Each hundred points describes on the screen a circle , and thanks to this there is the possibility of determining the duration of individual electric oscillations , originating in the brain. V.Gray-Walter uses a toposcope of different construction. In his instrument close to each other are situated 22-25 cathode ray tubes, the rays on the screens of which execute a continuous movement over the spiral. The brightness of illumination offers the possibility of determining the magnitude of the potential. The length of travel of the luminant point, moving over the spiral, allows to determine the nature of the rhythm existing in the brain. To analyze electroencephalograms is also used the method of simultaneous recording of biopotentials, taken from 16-25 points of cortex cerebri, whereby all rays on the screen of the encephalograph are brought at the beginning into one point. Recorded is the discrepancy of lines on the screen of the CRT. The smaller the discrepancy, the closer is the agreement of the plotted

curves, the more sharply is expressed the synchronization of electric processes in the brain. This analysis method is very simple and descriptive.

Perkins and Levin gave a report on telemetering registration of electroencephalograms of a nonnarcotized animals. Derivation of the biopotential from cats they realized with the aid of electrodes planted over the brain. The radio transmitter, modulating the electroencephalogram, is attached to the back of the animal. At first amplitude modulation was used , replacing it later by frequency modulation. After detection and demodulation electroencephalograms are recorded with the aid of an electron-ray oscillograph or on a magnetic tape. This method is useful for studying electroencephalograms under conditions of free behavior of the animal.

A number of important investigations was discussed at the sessions, devoted to the use of electronics for studying blood circulation systems. Of a greater number of reports we will mention the one by Welles and coworkers concerning intracardiac phonocardiography. The lecturers constructed a miniature piezoelectric microphone, containing barium titanate crystals . This microphone is attached to the tip of the catheter, which is inserted in the cavity of the heart. According to the authors, such a method of registering phonocardiograms has advantages over the outer ordinary photocardiography.

The japanese researcher Satomuro and coworkers developed an ultrasonic cardiograph, based on the Doppler effect, and ultrasonic rheograph to determine the intensity of blood circulation. The working principle of these instruments consists in the change of signal wavelength, of the signal reflected from the moving object. Employed is also ultrasonic cardiography, based on the principle of ultrasonic echo depth finder, used in sea operations to measure depth. Methods of ultrasonic cardiography and rheography have, apparently, certain perspectives for cardiology.

Presented were also data on the study of the regional vascular resistance with the aid of electromagnetic rheographs. Goldy reported about phonocraniography -method of registering intracranial noise, connected with the movement of the blood over the

vessels of the brain.The method is based on the use of an electronic stethoscope and may be important in clinic.

Among the reports,devoted to methods of studying the functions of the cardio-vascular system, we will mentionthe report by S.Larx on electrocardiography of fetus. The authorshowed the possibility of registering an electrocardiogram of a fetus by applying electrodes to various parts of the abdomen of a pregnant women. In this way it is possible to determine the position of the fetus in the womb (head up or down), to detect twins and diagnose long before the genus the inherent defects of the heart of the fetus.

D.Green offered data on automatic regulation of blood pressure level during surgical operationa. For this purpose,the arterial pressure of the patient, placed on the operating table, is being registered continuously. At a rise or drop in pressure to above or below the specified given level the "follow-up" system automatically connects an instrument with a syringe for intravenal introduction of a substance,increasing or decreasing the vascular tomus.

In 2 reports by Montgomery, Stefenson and Batson and Elmquist were elucidated new achievements in the method of electrically stimulating the heart. Montgomery and his co-authors developed an apparatus,allowing to establish artificial communication between the auricles and ventricles in cases of damages of the conductive system of the heart and during atrioventricular blockades. The potential derived from the auricle - serration P of the electrogram - appears to be a signal ,activating the electronic stimulator , sending an electric pulse to the ventricles of the heart. The electronicarrangement includes a relay, by means of which the stimulus goes to the ventricles with a delay of 0.15 - 0.18 sec in comparison with the time of pulse origination in the auricle. This delay corresponds to the one which takes place when the pulse passes normally through the atrioventricular unit. (joint).

Elmquist developed two kinds of electronic semiconductor stimulators. They are implanted in the human body and connected with the electrodes ,introduced into the

ventricles of the heart. Elmquist's instruments have the form of watches with a diameter of 6 cm and about 2 cm in thickness. They are covered with a plastic cover, not irritating bodily tissues. At the output of the instrument can be obtained stimuli with a voltage of 2.5 v, duration of 10-12 m/sec, with frequency of 70-80 stimuli per min. The instrument is powered from a small size battery, continuous operation of which is intended for 7-8 days. Charging the battery is done by remote induction current by means of a greater induction coil, placed above the person. Such a stimulator, coupled with electrodes, implanted in the myocarditis , was implanted in the summer of 1960 in a patient admitted to the Saint George hospital in London. The patient, the heart of which functioned in the rhythm of the stimulator, was released from the hospital. Once a week he appeared at the hospital for charging the battery, which was done at night when the patient was sleeping.

The electronic circuit of the second Elmquist stimulator is powered from a small size mercury battery, which can work continuously for a period of 3 years. This was attained by changing the electronic circuit, allowing to reduce to several micro amperes (instead or ordinary milliamperes) the necessary amperage of each pulse. If within 3 years after implanting the stimulator it is necessary to change the battery, then this can be done by a simple surgical operation, at which it is sufficient to make an incision in the skin and subcutaneous cellular tissue.

A considerable number of reports was devoted to electronic methods of studying the functions of breathing. Among these report attention is merited by the one presented by D.Hill, M.Stallard and L.Moline ,devoted to modern methods of analyzing gases,

participating in the breathing. At present time was developed a multitude of instruments for analyzing gases based on the study of various physical and physico-chemical phenomena. For quantitative investigation of the content of individual gases in the air is applied mass-spectrometry, gaseous chromatography, paramagnetic properties of certain gases , polarography, glowing discharge

in rarefied gases, absorption of infrared rays, which is different for different gases, various rates of noise travel in gaseous mixtures of various composition and difference in electroconduction. The most perspective appears to be, evidently, the use of the mass-spectrometry principle, allowing to carry out with sufficient speed a continuous registration of changes in the composition of gaseous mixtures. This method offers the possibility of determining the concentration of various gases of inhaled air and in narcotic mixtures as well. The method is so sensitive, that it allows to catch the changes in the composition of alveolar air within a period of one respiratory cycle. Less sensitive is the analysis method, based on the principle of gas chromatography. It does not give the possibility of catching a rapid change in the composition of a gaseous mixture, but otherwise it is absolutely accurate and reliable.

The founder of the method of roentgendesigraphy (kymodensigraphy) M. Marshal presented a report on the use of the developed by him method of studying pulmonary blood filling. The method consists in registering with the aid of a photoelement the changes in illuminosity of the x-ray screen when x-raying the pulmonary tissue. As was shown by previous investigations of Marshal, the density of the pulmonary tissue with respect to x-rays changes within each heart cycle in connection with the change in blood filling. In this way, are recorded the pulse fluctuations of pulmonary vessels. The roentgendensigraphy method offers the possibility of early diagnostication of lung tumors.

Hesse described a new type of sensing element for electric registration of respiratory movements, applicable also for investigating in certain other motorial phenomena in the organism. The sensing element represents a thin rubber tube, in both ends of which are mounted electrodes. The tube is filled with a colloidal graphite solution. Upon extension or contraction of the tube there is a change in ohmic resistance of the conductor filling the tube. With the aid of such a sensing element it is possible to realize highly sensitive registration of motorial phenomena and changes in volumes

of organs. In the words of the author, who developed this type of converter of mechanical values into electric signals, it has advantages over rubber-mercury sensing elements, which have been used in recent years.

From reports, devoted to electronic methods of investigating the locomotorial apparatus, is worthwhile the report by Sweetenheim concerning the problem of using biocurrents of muscles in controlling protheses. As is known, such investigations are being conducted for several years in Moscow at the Central Institute of Prothesization.

R. Tait reported about devices for the obtainment of artificial voice. The apparatus is placed in the mouth and it offers the possibility of reproducing words of people, undergoing operational removal of larynxes.

In several reports, in the Houry report in particular, were shown the diagnostic possibilities of ultrasonic location of malignant tumors in various organs of the body - in the mammary glands, liver, stomach, larynx, thyroid glands etc. Under the effect of the ultrasonic probe on calcified heart valves during open heart surgery there may be a disruption in the calcium depositions without harm to the soft tissues. By applying a fixed ultrasonic beam it is possible to selectively disrupt strictly defined structures of the brain (report by Frey). With the aid of this method are possible, so to say, bloodless surgical operations, offering a positive effect during parkinsonism, forced movements, phantom pains etc.

Several reports were devoted to problems of biological effect of electromagnetic radiation of ultrahigh frequencies (centimeter waves). It is the opinion of a majority of researchers, that the general effect of microradiowaves on the organism is connected preferably with their thermal effect. The authors made efforts to establish the threshold values of field intensity. Together with the thermal effect are noticed also certain other effect of microradiowaves, which may serve as indications of their specific effect on tissues.

At a special session were discussed problems connected with the use of endoradiosounds ("radio globules") to study the functions of the alimentary tract.

Developed back in 1957 by V.K.Zvorykin (USA and M.von Ardene (German Democratic Republic) radio globules represent miniature radio transmitters, easily swallowed by persons and sending information about the active reaction(pH), pressure and temperature in the stomach and intestines.

Radio globules, intended to study the acidity of stomachic juice , developed by Neller, offer the possibility of making determinations within pH limits ranging from 1 to 8 with an accuracy of up to 0.1. The diameter of these globules is 8 mm, 18 mm long. A pill (globule) carries a 1.25 v battery in form of a disk 7 mm in diameter and 1.5 mm thick. The battery can function continuously for 20 hours. The generator of the radio transmitter produces a frequency of 1.8 mc. At extreme limits of pH changes the frequency of the generator changes to 120 kc. The radio receiving device is equipped with a dial type instrument, which is precalibrated by submerging the globule in solutions with known pH. The indications of the radio transmitter can be recorded in form of curves. Investigation of acidity of gastric juice by this method allows to make a number of functional tests. And so, introducing into the stomach a known amount of water and by changing in this way the acidity of the gastric juice, it is possible by arithmetical calculations to determine the amount of gastric juice. By introducing alkaline it is possible by the rate of the subsequent rise in acidity of the gastric content to determine the rate of acid secretion. This indicator,being of great importance in the evaluation of the physiological condition of gastric glands, could not be investigated by previously ordinarily used methods - by the introduction of a probe into the stomach.

Radio globules, intended to study motorial functions of the alimentary tract, offer the possibility of determining pressure in the stomach and intestines (within limits of up to 50, 100, 150 cm of water column). The lowest value of the determinable pressure is 0.25% of absolutle scale. Ordinarily an inductive pressure transmitter is used (coil inductance 150 microhenries). The electric circuit of the radio globule consits of generator on point semiconductor germanium triode with grounded collector.

The frequency of the generator 1.8 mc in von Ardene globules and 450 kc in Solartron globules. The oscillatory circuit of the generator consists of in-series connected transmitter coil and metal-paper capacitor. Upon a pressure change of 100 mm water column in the von Ardene globules takes place a change in frequency of the magnitude of 15 kc, and in the Solartron globules - 35 kc. The signal picked up by the antenna is demodulated and it has a potential, proportional to the pressure, affecting the sensing element of the globule. Linearity of indications reaches 2% of absolute scale. The battery of the pressure radio globule works for about 75 hrs.

At the conferences were presented four reports of Soviet scientists. V.V.Parin gave a review of the ballistocardiographic investigations being conducted in the USSR. The lecturer presented data on the broad application of this investigation method to study cardiac activity in our country and described the basic results obtained with the aid of this method.

The report by V.A.Kozhevnikov was devoted to modern methods of analyzing electroencephalograms. A considerable part of the report contained an explanation of the original investigation of the author, which were published in Soviet scientific journals. Z.V.Gordon (a female) reported about the biological effect of microradiowaves and about methods of protecting against same. In the report were given the biologically permissible limits of electromagnetic field intensity. Characteristic is the fact, that the soviet researcher gave much lower numbers of permissible radiation intensity than foreign lecturers.

Yu.Ye.Moskalenko in the report "Characteristics of Absorption of UHF radiations by Tissues of the Organism ", reported on the results obtained by him during biophysical investigations and explained the method of investigating cardiac activity by passing ultrashort radio waves through the thorax.

Evaluating the results of the London international Conference on medicinal electronics, it should be pointed out, that a majority of presented reports was distinguished by the newness of the material and perspectiveness of mentioned investiga-

tion methods. Electronics has firmly established itself in biological, physiological and medicinal undertakings. It is impossible not to agree with the statements frequently sounding at the conference and concerning the desirability of further strengthening the creative bonds between biology, medicine and electronics, which have been established in recent years.

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